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Art. I.—*On Contusion and Contused Wounds of Bone, with an Account of Thirteen Cases.* By John A. Lidell, A. M., M. D., Surg. U. S. Vols., Inspector Med. and Hospital Department Army of the Potomac.

The osseous framework of the human body is exposed to a considerable variety of lesions occasioned by violence; and, if we inquire at length into the causation of these injuries, it will be found that they are the necessary results or products of physical forces brought into activity by accidents, by design, or by war. The traumatic lesions of bone embrace a wide field, and present a subject of deep interest to every surgeon. An enumeration of the most important of them will assist us to estimate aright the extent and importance of the subject. Considered apart from the injury of the soft parts with which these osseous lesions may be accompanied, they embrace *firstly, simple fracture; secondly, comminuted fracture, i. e.*, fracture with splintering, shattering, or crushing of the broken bone, and *thirdly, wounds of bone.* The term fracture can, with propriety, be applied only to a forcible solution of the continuity which extends through the whole thickness of a bone; while the term wounds of bone embraces those other solutions of the osseous continuity, occasioned by violence, which do not extend through the whole thickness of it.

The wounds of bone are analogous to the wounds of the soft parts, and, like them, may be classified as follows: First, *incised wounds*, of which familiar examples are afforded by a cut into the tarsus inflicted with the sharp edge of an axe, or by a piece of the skull shaved off with a sharp sabre or cutlass. Second, *lacerated wounds*, an example of which is afforded by the coronoid process of the ulna when torn off by the action of the brachialis anticus muscle. This form of injury may be denominated a lacerated wound of the ulna, or a fracture of the coronoid process. Another example of this lesion is afforded by a long splinter torn off from the side of a long bone by a rifle-ball. Third, *contused and lacerated wounds*, such as a groove or furrow ploughed on the surface of a bone by a musket-bullet. Fourth, *contused wounds*, properly so called, examples of which are produced by glancing balls, by spent balls, and by severe blows with any blunt instrument, whereby the external compact layer of a bone becomes cracked and perhaps indented also, while the investing periosteum and the underlying osseous tissue, at the same time, receive an injury in the nature of a bruise. Fifth, *perforating wounds*, such as, for example, a hole bored through the whole thickness of a bone by a gimlet or drill. Rifle-balls also sometimes pass through the condyles of the femur, the head of the tibia, and other portions of the osseous system, in such a way as to produce examples of this kind of injury. Sixth, *penetrating wounds*, instances of which are not unfrequently produced by small arms, as when a bullet passes through the body of a vertebra and lodges in the spinal canal, or penetrates the shaft of a long bone and lodges in the marrow, or penetrates its spongy epiphysis and lodges in the cancellous structure.

Besides the various forms of solution in the continuity of bone enumerated above, the osseous tissue is liable to be injured by violence in two other ways; viz., during the infantile period of life and before the calcification of the osseous tissue is far advanced, any of the long bones may be forcibly bent without fracture, numerous examples of which are on record; and, in the second place, *the osseous tissue is liable to be bruised*, there being, at the same time, no manifest disruption of the external compact layer, or any other part of the bone involved—a form of injury not unfrequently inflicted by spent musket-balls, by glancing musket-balls, and by the kicks of horses or mules. This kind of injury of the osseous tissue is properly known as *contusion of bone.*

For the purposes of clinical study and investigation, all the cases of traumatic lesion of the osseous tissue may be conveniently arranged in three principal groups. First, injury without solution of the continuity, *e. g.*, the contusion and the bending of bone. Second, partial solutions of the continuity, *e. g.*, the various wounds of bone; and third, complete solutions of the continuity, *e. g.*, fracture. By pursuing this course we are enabled to keep the extent and magnitude of the subject constantly before our minds, and, at the same time, devote ourselves to the study of any part of it without embarrassment.

The pathological history of contusion of bone will constitute essentially the theme of this paper. It is a subject which, heretofore, seems not to have attracted much attention. Nearly all of the systematic works on surgery, in common use in this country, such as those of Gross, Druitt, Smith, Ferguson, Miller, and Chelius by South, make no mention of it whatever. Mr. Erichsen alone gives a brief account of it. Even in the books devoted to a special discussion of the diseases and injuries of the osseous system it is entirely overlooked. Mr. Stanley,[1] in his valuable work on the bones, and Mr. Paget, in his admirable lectures on surgical pathology, do not make any allusion to such a pathological condition of the osseous tissue as contusion. The writers on military surgery, for example, the late Mr. Guthrie, Dr. Macleod, Mr. Longmore, Dr. Williamson, Sir George Ballingall, and Dr. Hennen are equally silent on this subject in their respective works. Dr. Stromeyer, however, forms an exception, as he speaks of it while describing the action of bullets on the bone. He says:—

> "They strike the bone without breaking it. and flatten themselves against its surface; the bone struck becomes necrotic from the destruction of its periosteum. In crowded hospitals such injuries of the larger long bones cause suppuration of the medullary canal, which, extending itself, at last by the passage of pus into the veins gives a fatal termination. In the autopsy (the bone being sawn in its long axis) the marrow is found filled with pus from the wounded part upward, and the same morbid product in the neighboring large veins, as in the femoral vein after contusion of the femur.
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> "The spot struck by the ball is colourless and exsanguine; in its circumference appears the commencement of a line of demarcation. Contusions of this kind, which, up to the present time, have been but little attended to in the long bones, are well known in the bones of the skull; when caused by a blow or fall, they have the same dangerous consequences, if not properly treated, as suppuration occurs in the diploe and purulent inflammation in the sinuses, with its usual results. Such contusions also occur in the cranial bones if a bullet strikes at a right angle, of which I have seen many examples, where it could be determined from the character of the wound in the soft parts that the same had been so struck without causing fracture or depression of the bone."—Vide *Statham's Stromeyer*, pp. 12 and 13, American edition.

But while Stromeyer thus distinctly recognizes the occurrence of contusion of bone, and, furthermore, that it is a lesion often fraught with great danger to life, he does not enter upon any extended discussion of the subject. He speaks of this form of contusion as he has seen it in the shafts of the long bones and in the bones of the cranium, but without the mention of any others. He does not attempt to point out the several varieties of osseous contusions, although they differ from each other very much, both in respect to phenomena and results. Nevertheless, he is entitled to no small amount of credit for having clearly pointed out the great danger to life which pertains to many cases of this kind of injury.

THE CONSEQUENCES OF CONTUSION OF BONE. *First. Ecchymosis of the Osseous Tissue.*—As already indicated above we find on investigation that the phenomena of the kind of injury under consideration do not, by any means, present a uniform character. They vary a good deal, according to the situation, structure, and vitality of the bone which happens to be bruised. For example, a contusion of the bones of the face (*cæteris*

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[1] This statement is made from memory alone so far as Mr. Stanley's book is concerned, and here in the field, where this paper is being prepared, it is impossible to verify the statement by referring to the book itself.

paribus), is much more likely to do well than a contusion of the pelvic bones, and a contusion of the humerus than a contusion of the femur. This fact should, without doubt, be attributed to the superior supply of blood, and to the superior vitality which belongs to the osseous tissue in the upper part of the body when compared with that in the lower part of the organism. The structure of the injured bone itself has also an important bearing upon the pathological condition produced by the contusing force. For this reason the marks of a bruise are much more obvious from the very outset in a bone having a loose spongy structure, such as the condyloid epiphysis of the femur, than in one which is principally made up of compact tissue such as the diaphysis of the same bone. Furthermore, the pathological appearances produced by contusion in the spongy or cancellous osseous tissue bear a much stronger resemblance to a bruise of the soft parts, than the pathological appearances produced by contusion in the compact osseous tissue. This interesting fact tends to confirm the propriety of studying the lesions of bone by the light afforded from analogous lesions of the soft parts. Now, contusion of the soft tissues is always associated with an extravasation of blood into the meshes of the areolar tissue, called ecchymosis. This takes place from the capillary bloodvessels which happen to be ruptured by the contusing force. In like manner contusion of any bone having a spongy structure, such as the inferior epiphysis of the femur, *may* also be accompanied by an ecchymosed appearance of the bruised osseous tissue, occasioned by the extravasation of blood into the cancelli from the capillary vessels, which chance to be ruptured by the commotion among the osseous particles set up by the contusing force. The following case affords a good illustration of this point.

CASE I. *Gunshot wound of the left knee-joint with contusion of the internal condyle of the femur; ecchymosis of bruised osseous tissue; traumatic arthritis; secondary amputation of the thigh; recovery.*—Private Jacob Kimm, Co. E, 152d New York Vols., aged 21 years, and of good constitution, was admitted to Stanton General Hospital, June 4th, 1864, from the field, having received a severe gunshot wound of the left knee-joint, four days previously, May 31st, near Salem Church, Va. A rifle ball penetrated that joint from the front. There was no orifice of exit. He said the ball had not been extracted, and it was therefore supposed to be still lodged somewhere on the inside.

June 6. The knee is much swelled, painful, hot, and tender. The periarticular tissues are thickened by serous infiltration. The thigh, also, is moderately swelled; and the femoral tumefaction is increasing from day to day in spite of quietude, and a free application of ice to the inflamed parts. A thin and dirty looking pus mixed with synovia flows from the wound. On introducing my finger, the patient being etherized, the interior of the joint is readily explored in various directions, but without discovering the bullet or finding any comminution of the bone. His general condition is favourable. The constitutional disturbance (irritative fever) is but slight, having not yet been fully developed. There being no prospect of saving the limb the thigh was amputated this day by the double-flap method about the junction of the middle with the inferior third; anæsthetic sulphuric ether. The loss of blood was small. But little shock attended the operation, and he reacted promptly after it. The subcutaneous areolar tissue was œdematous at the place of operation.

The after-treatment presented no difficulty. The stump united by granulation. The convalescence was rather slow, but satisfactory in every other respect.

Oct. 10. He has a good stump and expects to be discharged from the service in a short time.

The examination of the amputated member showed that the bullet had penetrated the joint, struck against the fore-part of the internal condyle of the femur and *bruised* it. But the projectile was not found in the joint or any of the neighbouring parts, and, therefore, it is supposed that it had either fallen out spontaneously, or had been withdrawn by the clothing. It was doubtless a spent ball. The synovial membrane was reddened (inflamed) throughout its whole extent. The synovial fringes exhibited the greatest amount of the reddening. The joint contained a quantity of thin, dirty-looking, flaky pus. The bone was not broken nor indented at the spot where the bullet impinged against it, but was only *bruised.* On sawing through the seat of the *contusion* the cancellous structure was found to exhibit pretty *extensive ecchymosis* in that locality. This *ecchymosed patch* was about an inch in diameter by something more than half an inch in depth. This *bruised* portion of the femoral condyle blackened by the extravasation of blood into its cancelli was surrounded by a sharply defined margin, which separated it from the healthy osseous tissue lying exterior to it.

In this man's case but six days elapsed between the infliction of the injury and the amputation of the injured member. This brief interval afforded too little time to allow any considerable development of the after-phenomena peculiar to ecchymosis of bone. But it is sufficiently obvious, that, whatever science may have lost from not delaying the amputation till a later period, the patient himself gained in the additional security to his life obtained thereby, since the knee-joint was involved in the traumatic lesion. It is, however, not difficult to conjecture some of the terminations which must follow after ecchymosis of bone, if we permit our reflections to be guided by the general analogy which obtains between ecchymosis of the osseous and ecchymosis of the soft tissues, and provided that we also make the necessary allowances for the differences in anatomical structure pertaining to the osseous and the soft tissues, and for the modifications in morbid action consequent thereon, being careful to pursue our reflections in a strictly philosophical spirit. For example, there is good reason to believe that the so-called interstitial absorption of the extravasated blood may take place spontaneously in some cases of ecchymosed bone, as well as it does in most cases of ecchymosed soft parts, and that in this way the lesion may terminate directly in recovery without the intervention of any morbid process whatever; or, in other words, it is possible that ecchymosis of bone may terminate spontaneously by resolution through the activity of certain of the normal physiological processes alone. Something analogous to this we sometimes see, when a small ecchymotic extravasation of blood has occurred beneath one of the finger nails from a slight bruise. In such a case it happens that the overlying nail does *not die*, but the extravasated blood itself begins to disappear at the circumference of the bruise, and this process continues until the discoloration is wholly removed. And not the least interesting feature in such a case is, that we can readily see through the semi-transparent nail the progress towards recovery by resolution of an extravasation of blood beneath dense tissue, from one day to another.[1]

But there is also good reason to believe that ecchymosis of bone is not always attended with so fortunate a result. Now, in a case of *severe contusion* of any of the porous or spongy bones it is obvious that the quantity of blood extravasated into the cancelli of the bruised osseous tissue would be materially increased in such a way as to bear some relation to the severity of the contusion, and it is not difficult to conceive that the increased volume of the sanguineous effusion might be so great as to fill up the cancelli and the minute canals of the bruised part of the bone completely, and the tendency (*vis à tergo*) to extravasate continuing would extend the disastrous effects beyond this, and might even compress effectually the nutrient capillary bloodvessels against the hard unyielding osseous partitions, plates, and laminæ in relation with which, and in the midst of which they course along, and thus cut off completely the supply of blood to the ecchymosed osseous tissue. In this way the nutrition of the bruised portion of bone would be arrested, and a morbid condition, a necrosis, a dry gangrene of bone, analogous to senile gangrene of the soft parts, would be produced. In this way the blood extravasated into the cancelli, and the interspaces of bruised osseous tissue would destroy the vitality of that tissue as effectually as the products of inflammatory action sometimes do when they are suddenly effused into the interior structure of bone. In both alike necrosis is produced, and the inability on the part of the calcified osteine to stretch and yield, and thus permit swelling to take place so as to save the interior nutrient bloodvessels from compression, is mainly chargeable with its production.

The following case has an important bearing upon this part of the discussion. It affords a striking example of circumscribed necrosis, produced by the extravasation of blood into the porous structure of the inferior epiphysis of the femur. It shows, further, that the osseous tissue, whose vitality has been destroyed in this way, acts as a mechanical irritant upon the contiguous structure just like any foreign body; and that it may kindle in them an inflammatory action of great severity and of a fatal character.

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[1] There is reason to believe that ecchymosis of bone from contusion occurs much more frequently than at first sight would be supposed; and that its termination by resolution accounts for the fact that it very often evades the surgeon's notice.

CASE II. *Contusion of the external condyle of the left femur inflicted by a glancing bullet, followed by severe inflammation of the knee-joint, although it had not been penetrated by the bullet; death from exhaustion after thirty-six days: ecchymosis of the bruised osseous tissue found at the autopsy.*—Private Thomas Pryor, Co. "H," 18th Mass. Vols., aged 19 years, was admitted to Stanton General Hospital, May 25, 1864, from the field, having been wounded at the battle of the Wilderness, May 5th, twenty days before, by a glancing minie-ball, which caused a superficial wound of the skin, and subcutaneous areolar tissue on the outer side of the left knee; but the joint was not opened by it.

He exhibited all the local symptoms of a *very severe inflammation of that joint*, besides which he suffered much constitutional disturbance in the shape of *a very low form of irritative fever*, and died of exhaustion, June 10th.

It was found at the autopsy that the *external condyle* of the left femur was *contused by the glancing bullet*, although the synovial sac was not penetrated by it. The *contused bone exhibited well-marked ecchymosis* through a circular space about one inch in diameter by three-fourths of an inch in depth, *and was surrounded by a distinct line of demarcation*, which was clearly shown by sawing through it. The contused portion of bone had a dark reddish-brown color. The interior structure of the epiphysis in general was redder than natural.

This case, reported at greater length, can be found in the last number of *The American Journal of the Medical Sciences*, Vol. XLIX. It is again introduced in this place, because it affords an apt illustration of the views just now expressed concerning ecchymosis of bone terminating in necrosis. Here we see an example wherein the extravasation of blood into the tissue of a spongy bone, occasioned by a bruise, was sufficient to arrest the supply of nutritive material to that portion of bone; and, in this way, deprive it of vitality, as has already been pointed out. Here we further see an example of the destructive results which may speedily follow necrotic ecchymosis of bone occasioned by severe contusion. The dead bone itself, like a foreign body, irritates the surrounding parts, and kindles in them an inflammatory condition as destructive to life as it is violent and prolonged.

The Second Important Consequence of Contusion of Bone which demands our attention is Ecchymosis of the Medullary Tissue.—This pathological condition is found only in the marrow of the long bones, and seems not to be accompanied by ecchymosis of the neighbouring osseous tissue; at least, this rule has obtained, in the several cases which have come under the writer's observation. While ecchymosis of the osseous tissue itself is confined to the spongy epiphyses, so far as the long bones are concerned, ecchymosis of the marrow is restricted to the limits of their diaphyses. It may, with propriety, be stated in a general way in this place, that the phenomena of contusion of the shaft of the long bones are somewhat different from those which pertain to contusion of bones having a spongy or cancellous structure. The phenomena pertaining to the latter have already been considered at sufficient length. Now, when the shaft of any long bone, the compact tissue of which is very dense, and embraces the whole thickness unto the medullary canal, suffers contusion, no appearance of ecchymosis, appreciable to the unaided vision, will be discovered in the osseous tissue itself, on account of its want of sufficient porosity; but, at the same time, the commotion occasioned by the contusing force may be propagated inwards to the medullary canal, the capillary vessels therein may be ruptured by the force so propagated, and blood in abundant quantity may be extravasated into the marrow, causing it to present a bruised appearance. This is precisely what we have met with in several instances; and the following is a case in point.

CASE III. *Gunshot wound through calf of left leg; contusion of fibula with simple longitudinal fissure and extravasation of blood in the marrow; death thirty-five days afterwards from exhaustion.* Reported by Frederick Rorback, Medical Cadet, U. S. A.—Private James Sted, Co. "F," 20th Michigan Vols., aged 27, constitution apparently not vigorous, was admitted to Stanton General Hospital, July 4, 1864, suffering from a gunshot wound through the calf of the left leg, the missile being a minie-ball which had passed in close relation to the fibula. The wound had been received, June 28th, in front of Petersburg. At time of admission the orifice on the outer side of the leg presented a sloughy appearance. The one on the inner side also looked sloughy, but not so much so. Subsequently, the wound was treated with a solution of permanganate of potassa, under which it soon cleaned off, and the entire surface assumed a healthy granulating appearance.

At time of admission the patient's general condition was fair; but he was rather weak and debilitated. His appetite, however, was good. Quietude was enjoined, and nutrients and tonics were prescribed.

On the 5th, and again on the 12th of July, his bowels being torpid were moved by Sal. Rochelle. At this time stimulants began to be sparingly administered, as he appeared to be failing.

July 19. He was obviously much worse (asthenic), and complained of having a great deal of pain in the wounded parts. Milk-punch in very liberal quantity (so as to take ℥iss of spiritus frumenti every three hours), and pil. opii gr. j every four hours, were prescribed.

28*th*. His bowels became obstinately constipated. He continued to sink, and died, August 1st, of exhaustion. He did not have chills or febrile movement at any time; but slowly pined away, and died.

The autopsy disclosed the fact that the bullet had *bruised the fibula* on its outer surface at the upper third (junction with middle). Here the periosteum was reddened, thickened, loosened, and could be stripped off very readily for a distance of about three inches, but it was not yet completely separated. The osseous surface itself was considerably redder than natural, and roughened over the same space. The compact tissue was fissured longitudinally (a simple crack) at the place of contusion, and the crack extended into the marrow. There was also an old *extravasation of blood in the medullary tissue at the place of contusion.* It was dark-brown, or almost black in color, and occupied the whole thickness of the medullary canal through a space about one inch long; it appeared to date from the contusion. Above this extravasated blood the *red inflammatory marrow of Virchow*[1] was seen.

The tibia was not injured; but the soft parts of the leg were a good deal swelled, and infiltrated with the products of inflammatory action.

The exact diagnosis in this case was not determined until, after death, an autopsy was made; but the existence of contusion of at least one of the bones of the leg was suspected during life, although an exploration of the wound with the finger always showed that the osseous tissue was not denuded of its periosteum, and that necrosis had not taken place. This suspicion grew out of the unsatisfactory progress of the case. The leg continued to be swelled and inflamed. The wound continued to discharge, and showed but little inclination to heal. The patient's strength slowly wasted away; and all this occurred without obvious cause. The wound of the soft parts was not complicated with fracture. The irritation in the surrounding tissues was not kept up by the presence of any foreign body. This had been demonstrated more than once by careful exploration with the finger. To what then could we attribute the adverse progress of the case? Having previously had some experience with contusion of bone, we were led to suspect that this patient was suffering from such a contusion, and from the morbid condition of the bone itself, and of the neighbouring soft parts, together with the system at large induced by it.

Here, then, was the gist of the matter. An inflammatory irritation[2] had been lighted up in the bone, the periosteum, and the marrow by the contusing force of the bullet, and by the presence of extravasated blood in the marrow. If such inflammatory irritation had not occurred, it is highly probable that the wound would have got well without any trouble, and if, at any time in the progress of the case, this irritation had ceased, the morbid condition of the soft parts would have soon disappeared. It is also highly probable that the bruised condition of the medullary tissue, and likewise the blood extravasated into its meshes, had a good deal to do with keeping up the inflammatory irritation, both local and general, and with continuing the exhausting drain upon the system occasioned by the suppuration.

Thus, the contusion of even a slender bone like the fibula, with moderate extravasation of blood into its medullary tissue, trivial as this injury may appear to be when isolated, and considered apart from its legitimate relations, became the cause of this man's death; and that, too, without having induced necrosis, or suppurative osteitis, or even periostosis.

This fact brings us to the consideration of another important consequence, in a pathological point of view, which may be produced by contusion of bone, viz., *Osteo-Myelitis of a Simple Character. This constitutes the third, in our order of enumeration, of the legitimate consequences of*

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[1] *Vide* Lectures on Cellular Pathology, p. 458.

[2] *Vide* Virchow's Lectures on Cellular Pathology, p. 429.

this kind of injury. The last case affords a very good illustration of the pathological condition of bone to which the term *simple osteo-myelitis* may be applied. But it will be recollected that, in that case, the contusion of the bone was accompanied by an extravasation of blood into the medullary tissue. A case of contusion of bone, in which inflammatory irritation in the osseous tissue has been kindled directly by the contusion, and without the intervention of ecchymosis, is more strictly typical, and will, therefore, more exactly illustrate this part of the subject. The next case affords such an example.

CASE IV. *Gunshot wound of left thigh, followed by typhoid symptoms; death on the forty-second day from exhaustion; contusion of the shaft of femur with consecutive osteo-myelitis discovered at the autopsy.*—Private John Anderson, Co. G, 76th N. Y. Vols., aged 30, born in Sweden, was admitted to Stanton General Hospital, June 12, 1864, for a gunshot wound of the left thigh in the upper third, inflicted in action at Cold Harbor, June 6th, by a conical musket-bullet, which penetrated the front of the limb at the inner side of the femoral vessels, and, passing backwards and outwards through the limb, lodged beneath the skin. It was extracted by an incision from behind. When he came to the hospital, six days after the injury, it was thought that the wound was only a flesh one. His general condition was fair, or rather below par, at that time. Simple dressings to wound were ordered, and nutrients and stimulants were allowed. Subsequently the wound did well, and he appeared in a fair way to recover for a time.

July 1. It was observed that he was failing in strength and emaciating. Stimulants and the supporting treatment were continued with tinct. ferri muriat.

Afterwards he sank into a typhoid condition, the skin becoming warmer than natural, but without sweats, the pulse frequent and feeble, the tongue dry and red, with almost entire loss of appetite. He also became somnolent, and towards the last it was difficult to rouse him. He did not have any chills. He died July 18th. The amount of discharge from the wound was at no time great, but the thigh remained swelled and inflamed all the while.

On making an *autopsy*, it was found that the bullet had struck the shaft of the femur on its postero-inner side, two or three inches below the trochanter, *grazing and bruising it.* The aperture of exit had healed. There was an abscess about the place of injury of the bone, as large as an orange, and pus had also burrowed among the muscles of the thigh. There was a large deposit of new bone about the contused portion of the femur. A longitudinal section was made with a saw. New osseous tissue was also found deposited in the medullary canal. The marrow presented the "red inflammatory" appearance described by Virchow.[1] There was no thrombosis, nor any lesion whatever of the veins and arteries. The cadaver was considerably emaciated, and resembled in its general appearance that produced by typhoid fever. There was no lesion of the intestines or any other of the internal organs. For an account of the autopsy and for much other interesting information concerning this case, the writer is indebted to Asst. Surg. George A. Mursick, U. S. Vols.

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[1] *Vide* Lectures on Cellular Pathology, p. 458.

The inflammatory irritation of the periosteum of the bone itself, and of the marrow, which was developed in this case, appears to have been a direct result of the contact between the bone and the bullet in motion (bruise). The morbid product of this inflammatory irritation[1] consisted mainly of deposits of new osseous tissue, both upon the exterior, and within the medullary canal of the femur, in the neighbourhood of the injury. The development of this new bone was accompanied by abnormal vascularity (redness) of the marrow, of the old bone, and of the periosteum. The consequence to the patient of this protracted inflammatory irritation of bone was, that the neighboring soft parts were kept in a swollen and inflamed condition, that an abscess formed, that pus burrowed among the muscles of the thigh, that irritative fever was established, and that, finally, death took place from exhaustion. In all its main features, this case coincides with the last.

It has already been stated in substance that the last two cases afford examples of a kind of inflammatory irritation resulting from contusion, which affects the periosteum, the bone itself, and the marrow, in such a way as to produce increased vascularity, denoted by redness (hyperæmia) of all those parts, accompanied by a bright red flesh-like appearance of the marrow, and by the formation of new bone in the medullary canal as well as in the parts outside of the external compact layer. Although, in both instances, this inflammatory irritation (simple osteo-myelitis) destroyed life, it produced such a result, not by the destruction of the bone itself, but by the mischief which it excited and afterwards kept up in the neighbouring soft parts, and in the system at large. In reality, these two cases furnish examples of osteo-myelitis with a tendency to hypertrophy, or the formation of an increased quantity of homologous tissue at the seat of irritation, the inflammatory action[2] being analogous in character to that which is called adhesive in the soft parts.

But contusion may, and often does, excite a more profound inflammatory action in the injured bone than that from the consideration of which we have now passed, and this osseous inflammation may be so intense as even to destroy the vitality of the shaft of a long bone to a very great extent, and in the course of but a few days.

This statement brings us to the consideration of *the fourth important consequence of contusion of the bone, viz., Necrotic Osteitis, or an inflammation of bone so severe in character as to terminate in necrosis.* Without doubt the periosteum and the medullary tissue also are involved in the inflammatory process, but the destructive action appears to be confined to the osseous tissue, and therefore the phrase, osteitis terminating in necrosis, seems to be more appropriate than that of osteo-myelitis having such a result. The following case presents a good illustration of extensive necrotic osteitis produced by contusion :—

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[1] Op. cit., pp. 429, 430.

[2] *Formative irritation.* Virchow's Lectures upon Cellular Pathology, p. 438.

CASE V. *Contused wound of left tibia from a minie ball; severe constitutional disturbance, with chills, beginning on the twenty-first day; osteitis and extensive necrosis of shaft of tibia.* Reported by Acting Asst. Surg. John B. Garland, U. S. Army.—Corp. Henry Rall, Co. D, 15th N. Y. Heavy Art., aged 22, and sound in constitution, was admitted to Stanton General Hospital, June 4, 1864. This man had been wounded near Old Church, Va., May 30th, by a minie ball, in the upper third of the left leg. The bullet passed across the tibia about four inches below the patella, bruising the bone, and slightly grooving its surface. He was somewhat debilitated, but, upon the whole, his general condition was not unfavourable. Ordered quietude, cold water dressing to wound, porter, and a nourishing diet. This method of treatment was continued for fifteen days. The suppuration was profuse, the limb a good deal swelled, and the wound did not incline to heal. The progress of the case was not considered unsatisfactory during this time, taking into account the presence of an osseous lesion.

June 18. He had febrile symptoms last evening.

19*th*. He had a chill this afternoon, and the wound looks inflamed. Prescribed quiniæ sulph. gr. vi, three times a day.

20*th*. He had another chill, and complains of much debility, with loss of appetite. The wound is more inflamed. Prescribed quiniæ sulph. gr. x, three times a day, ferri et potass. tart. gr. v, every four hours, and whiskey f℥j, every three hours. Directed also the ice-dressing to be applied to the inflamed part, and morphia to be administered to secure freedom from pain.

25*th*. The chills have stopped, but the febrile movement continues, and the wound is sloughing. The whole leg is swelled and painful. Prescribed a solution of permanganate of potassa (one part to four) to be employed as a cleansing wash for the wound; tinct. ferri muriat. gtt. xx, ter in die, in place of the tartrate of iron and potassa, morphia at night; the quinia, stimulant, and ice-dressing are to be continued.

27*th*. The patient is free from fever, and has a fair appetite. The sloughing has stopped, but the leg is much inflamed, tender, and painful. Stimulants, tonics, and anodynes continued.

July 2. The leg is much swollen, and very painful, and exhibits deep-seated fluctuation. Opened it freely by an incision about five inches in length. A quantity of matter was discharged. The periosteum was found to be extensively separated from the tibia, and the bone itself appeared to be extensively necrosed. Ordered same plan of treatment to be continued, with pulv. opii gr. j every three hours.

10*th*. A second incision was made in the swollen leg, with a view to evacuate the pus more completely. Directed the quinine to be suspended, and the ice-dressing, stimulant, and opium, in the same doses, to be continued.

14*th*. The patient appears to be doing well. He has a good appetite, and appears to be more hopeful and cheerful.

23*d*. He is doing well.

30*th*. The wound does not run as freely as desirable. The granulations have assumed a less healthy look. They are flaccid and pale. Prescribed unguent. resinæ.

August 1. He had a chill last night, and is now (morning) bathed in cold perspiration. He has lost his appetite. Prescribed quiniæ sulph. gr. x, three times a day, tinct. ferri muriat. gtt. xx, three times a day, alcoholic stimulants, and a flaxseed poultice to the leg, and he got better in a few days.

Sept 15. His general health is good. The leg now gives him but little trouble. There are several openings in the soft parts through which the tibia can be seen denuded of periosteum. The shaft of the tibia is extensively necrosed, and an involucrum developed from the periosteum is in process of formation.

Oct. 27. Examination with the probe shows that a large part of the shaft of the tibia is necrosed and loosened, but it is not yet sufficiently detached to justify removal by operation. The only treatment required during the past month has been poultices for leg, and a nourishing diet. His general condition is splendid. He has become quite fleshy. His appetite and spirits are excellent. At this time the writer relinquished the charge of the case, having been assigned to duty elsewhere, and therefore he is unable to continue the account of it.

He has, however, been informed by letter, under date of March 2, 1865, that the patient is still under treatment at Stanton Hospital.

In reflecting upon the clinical history of this case, it is interesting to notice that the osteitis which probably began on the 18th and 19th had terminated by destroying the vitality of a large part of the shaft of the bone involved (tibia) before the 27th. It is also interesting to notice the vigorous effort which nature made on the 25th to secure a free opening through the soft parts down to the inflamed bone, by causing the wound to slough. Again, an abscess formed in the soft parts about the bone which was laid open July 2 by an incision about five inches long, and the periosteum was then found to be extensively separated from the tibia. It became necessary to incise the leg extensively again on the 10th. From both of these incisions the patient derived much relief and much real benefit. Would he not have been benefited still more, if the leg had been laid open down to the inflamed bone, by long incisions, several days prior to July 2? Did not the sloughing, which attacked the wound June 25th, denote the necessity that existed for the construction of a freer opening? These questions bring up the subject of the treatment of contusion of bone, but as it can be more conveniently considered in another part of this paper, all remarks upon it will be deferred to that place.

There is one point in connection with the pathology of acute inflammatory necrosis which, perhaps, should be here brought more distinctly before our minds. It was briefly alluded to while discussing the *modus operandi* of necrosis produced by traumatic ecchymosis. In such cases, blood is extravasated into the interspaces of the osseous tissue, in such a way as to arrest the circulation in the portion of bone involved, by compressing the capillary vessels against the unyielding calcified osteine, which enters very largely into the composition of all osseous formations. In such cases, the death of the osseous tissue is occasioned directly by the arrested nutrition. Now, in cases of necrosis produced by inflammation of bone, the same result is brought about in a similar way. The main difference between the *modus operandi* of these two forms of necrosis is, that in one of them *blood* is extravasated into the osseous tissue, and in the other the *products of inflammatory action*[1] are exudated into that tissue. In the one case, the compressing agent is extravasated blood, in the other case, it is an exudation produced by the inflammatory process and poured out into the interspaces, more especially the canaliculi of the inflamed bone. It is, therefore, no longer a subject of wonderment that severe osteitis is very apt to produce necrosis.

Again, *another, and in point of number the fifth, sad consequence of contusion of bone* which has come under the writer's observation *is Suppurative Osteo-Myelitis*, or inflammation of both the osseous and the medullary tissue accompanied by the formation of pus in those tissues. The following case affords a good example of it:—

CASE VI. *Contusion of the shaft of the left femur by a grazing bullet; extravasation of blood into the medulla; extensive necrosis the sequel of suppurative osteo-myelitis; pus in the medullary canal; death on the fiftieth day.* Reported by Acting Asst. Surgeon Charles H. Osborne, U. S. Army.—Sergt. F. Waltz, Co. D, 8th Mich. Vols., aged 39, was admitted to Stanton General Hospital, July 4, 1864. He had been wounded in battle before Petersburg, Va., June 30th, by a minie ball, which, entering the outer side of the right thigh in the upper third, passed transversely through posterior to the bone; then, entering the left thigh, passed through it grazing the femur, and lodged beneath the skin, from whence it was extracted by a small incision. At the time of admission to hospital, both wounds were suppurating freely, and his general condition was poor. Full diet, tonics, and stimulants were ordered, with ice-dressings to the wounds. His bowels being constipated, sal Rochelle ℥j was administered. He complained of pain in the shoulders and upper extremities. His bowels remained obstinately constipated, and required occasionally laxative medicine until August 10th, when the opposite condition set in, and he had from three to four passages during the twenty-four hours, attended with rigors. Bismuth and opium were added to the treatment. The tongue became coated, he lost his appetite, and by August 14th all the symptoms commonly pertaining to typhoid disease were fully developed. The treatment now consisted of nutrients, stimulants, small doses of ol. terebinth. in emulsion, and quiniæ sulph. in solution. The discharge from the wounds became more profuse and thin. *He complained of great pain in the left thigh. Necrosed bone was detected* by examination with the probe. Opium was administered to allay the pain, and the diarrhœa was partially checked by injections of starch and opium. He gradually sank deeper into the typhoid condition, and died August 19th.

Autopsy twenty hours after death.—Cadaver extremely emaciated; muscles of left thigh infiltrated with pus; femur extensively denuded of its periosteum; necrosis of its shaft for two-thirds its length; a new bony deposit surrounds the femur at place of contusion; the lower three-fourths of the *medullary canal* contain a *thin, greenish-coloured pus*, which empties itself where the bone is denuded; the upper fourth contains *old clotted blood*. Pus to the amount of f℥j was found within the capsule of the hip-joint.

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[1] *Vide* Barwell on the Joints.

The lungs and heart were normal; liver slightly enlarged; spleen enlarged and soft; kidneys normal; Peyer's glands presented the "shaved chin" appearance.

The bullet had grazed and bruised the femur a short distance below the trochanters.

The porosity of the necrosed bone was very much increased.[1] It presented a worm-eaten or honeycomb appearance, which was most marked in situations where the periosteum had become detached. There was pus in the pores or interspaces in such localities.

This case presents an instance of inflammation of the osseous and the medullary tissue, occasioned by a spent bullet, still more unmanageable and destructive than any of the preceding ones, but, in view of what has been already said, it does not seem to require any extended comments.

There is *still another, the sixth, sad consequence of contusion of bone,* which has been witnessed by the writer. It is *Gangrenous Osteo-Myelitis,* or *a septic inflammation* of the osseous and of the medullary tissue, resulting not only in the death of those tissues, but in their *putrefaction and rapid disintegration.* The next case gives a good illustration of it.

Case VII. *Gunshot wound of left thigh, upper third, from a spent bullet; contusion of femur at root of trochanter major, with fissure of external compact osseous layer, but without indentation; gangrene of bone; pyæmia; death on the twenty-first day.* Reported by Acting Asst. Surg. John B. Garland, U. S. Army.—Corp. Thomas C. Cranston, Co. I, Sixth Michigan Cavalry, aged 25, was admitted to Stanton General Hospital, June 4, 1864. He had been wounded near Salem Church, Va., May 26, in the upper third of the left thigh, by a conical musket-bullet, which penetrated the limb obliquely from the front, and, passing backwards, upwards, and somewhat inwards, lodged deeply. He stated that the bullet was extracted on the field through the orifice of entrance. Prescribed water dressings, quietude, and nutrients, until he should recover from the fatigue occasioned by transportation.

June 5. The wound presents a very unhealthy appearance, and discharges a thin, dirty-coloured, extremely offensive fluid. He is feverish and restless, with considerable jactitation; tongue coated with white fur; bowels have been constipated for several days; he has also some difficulty in passing urine. Prescribed a wash of permanganate of potassa (ʒij to Oj) for wound, bowels to be opened with ol. ricini, and directed him to take spt. nitre dulc. gtt. xxx in flaxseed-tea three times a day.

6th. He is no better; is still feverish, and looking badly; bowels have not acted. Ordered magnesia sulph. ℥j.

7th. The Epsom salt has operated, and he appears to be somewhat better; passes his water better; but he is still depressed, and his appetite is poor. Prescribed quiniæ sulph. gr. vj three times a day.

9th. He had a chill last night; has vomited bilious matter; has fever, cough with rusty-coloured sputa, and hurried respiration; complains of pain in the side; complains also of great weakness; it is evident that pneumonia has supervened; it is also probable that the bone has been bruised by the spent bullet. Directed a large sinapism to be applied to the breast, six dry cups to the back, the quinia to be continued, sherry wine ℥j every two hours, with nutrients, and tepid sponging of the body under blankets.

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[1] Osteo-porosis (inflammatory). *Vide* Virchow's Lectures on Cellular Pathology p. 465.

11*th*. He is much worse; has pyæmic chills and sweats. Continue treatment, with the addition of whiskey ℥viij per day.

12*th and* 13*th*. The chills and sweats continued.

14*th*. He is lethargic, and evidently sinking.

15*th*. He died.

Autopsy twelve hours after death.—The bullet had penetrated the left thigh in the upper third, at the external border of the sartorius muscle, and passed backwards and upwards in such a manner as to hit the femur at the root of trochanter major, *bruising that bone*, and *cracking its external compact layer, but without indentation.* There were some small scales and particles of lead still adhering to the bone. *The whole of the superior femoral epiphysis was denuded of periosteum, and gangrenous, down to the commencement of the marrow. On section with a saw, the gangrenous osseous tissue presented a dirty dark-green or greenish-brown colour, and an offensive odour of putrefaction. There was an abscess in the marrow at the upper end of medullary canal.* The hip-joint was filled with unhealthy pus; no opening in capsular ligament.

The lungs were studded throughout with a large number of small whitish pustules, the so-called secondary abscesses, and the lower lobe of the right lung was hepatized (red). About three gills of lemon-coloured fluid were found in the pericardium. The heart was normal. Each kidney exhibited three or four small superficial abscesses looking not unlike pustules. The spleen was large, and exhibited also a few small superficial abscesses, with some induration of the tissue surrounding each of them. The liver and the other organs were normal.

The anatomico-pathological differences between the form of gangrene of bone presented by this case and ordinary necrosis are well marked. For example, a piece of necrosed bone is apt to be dry, white in colour, comparatively inodorous so far as the tissues entering its own composition are concerned, and it bears a strong resemblance to the ordinary bleached osseous tissue of the skeleton in appearance. But gangrenous bone, or rather the kind of it described above, is moist, dirty gray, dirty pale-green, or dirty greenish-brown in colour, and exhales to a greater or less extent the intolerably offensive odour of rotting bone. The writer has seen many other instances of this form of gangrene of bone connected with severe traumatic lesions of the osseous tissue, one of which, the case of Mackey, was reported in the last number of this journal (vide *American Journal of the Medical Sciences*, vol. xlix. p. 300, April, 1865). Some of them have occurred in connection with compound comminuted fracture of the femur, and others in the stump bones of amputated limbs. In the case of Mackey the compact tissue presented a white appearance, but the general features in all of them have been essentially the same, and of so marked a character as to make it not difficult to discriminate between the gangrenous bone and the morbid specimens of osseous tissue obtained from cases of ordinary necrosis.

It is worthy of remark that, in the case reported above, the gangrene of bone was accompanied by pyarthrosis of the hip-joint, and by pyæmia, with the so-called secondary abscesses peculiar to that disease. The same relation has obtained between gangrene of bone and pyæmia in other cases that have come under the writer's notice; but it has not done so in all of them, for in the case of Mackey the autopsy showed that there was neither thrombosis nor secondary abscesses in any part of the body, and the symptoms developed during life did not in any way favour the supposition that pyæmia had supervened.[1]

On Necrosis produced directly by the Contusion of Bone, without the Intervention of either Ecchymosis or Inflammatory Irritation.—Up to this point in the discussion our attention has been mainly occupied with the consideration of traumatic ecchymosis of the osseous tissue, and with the study of certain inflammatory conditions of bone produced not unfrequently by contusions, such as inflammatory necrosis, simple osteo-myelitis, suppurative osteo-myelitis, and gangrenous osteo-myelitis. In all these various pathological conditions of the osseous tissue, induced by injury in the nature of a bruise, the death of the osseous tissue involved (necrosis) has not been occasioned directly by the contusing force itself, but indirectly by the intervention of some pathological process, such as the extravasation of blood, or the exudation of some of the products of inflammatory action, into the osseous tissue, etc. etc. We now proceed to the consideration of a form of necrosis which is occasioned directly by the mechanical commotion set up among the osseous particles themselves, by the sudden application of sufficient force in the nature of a bruise, without the intervention of any pathological process whatever. In all such cases the injured part of the bone loses its vitality at once, and becomes colourless and exsanguine. This is the form of contusion of bone inflicted by a spent ball which attracted Dr. Stromeyer's attention. He says: "The spot struck by the ball is colourless and exsanguine; in its circumference appears the commencement of a line of demarcation." In all such cases a circumscribed portion of the osseous tissue is killed outright, and nature immediately commences preparations for its separation and removal from the living bone surrounding it. This form of osseous contusion may be produced by the kicks of animals, by blows, and by falls, as well as by spent bullets. The following case is an example of this kind of injury produced by a glancing bullet:—

Case VIII. *Gunshot wound of scalp and contusion of cranium inflicted by a glancing bullet; necrosis and exfoliation of the bruised*

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[1] This is not intended as a complete discussion of the subject of osteo-myelitis. The writer here speaks of that disease mainly as he has seen it in connection with one class of gunshot injuries, viz., contusion and contused wounds of bone.

osseous tissue; recovery. Reported by Acting Asst. Surg. W. B. Dick, U. S. Army.—Private Henry Abbott, Co. B, 32d Mass. Vols., was admitted to Stanton General Hospital, June 4, 1864, for a wound of the head inflicted a few days before by a glancing bullet. It struck him over the right parietal bone, thence passed forwards and downwards, exposing the temporal suture, and escaped, having made a wound of the scalp about three inches in length, and exposing the cranium. *The bone was not fractured.* The patient's general condition was excellent. He did not exhibit any cerebral symptoms worth mentioning. His bowels were soluble. Treatment: quietude, ice-dressing to head, tinct. rad. aconiti gtt. ij every three hours, and a spare diet.

June 7. He has diarrhœa, with six or eight evacuations in twenty-four hours. Prescribed opium gr. ½; acid. tannic. gr. j; pulv. camphor. gr. ij; to be administered after each passage. The diarrhœa ceased in a short time, and his general health continued good.

July 12. Removed a piece of necrosed bone about an inch in length by half an inch in breadth. It included a portion of the temporal suture, and was composed of the outer table and the diploe. The wound is filled with healthy granulations. The patient has good health. Prescribed the water-dressing in place of ice.

14*th*. Removed another piece of necrosed bone about half an inch in length, and corresponding to that already mentioned. It consisted of the internal table.

17*th*. Health very good; wound almost healed.

18*th*. Left the hospital, having been transferred to the North.

In this case a projectile fired from small-arms struck the cranium in such a way as to destroy the vitality of both tables over a considerable space, without producing fracture, or any solution of continuity whatever perceptible to the unaided vision. In the course of about six weeks the dead bone became detached, and was then extracted. In a few days longer the wound healed up. All of this took place without the occurrence of inflammation of the bone or of the adjacent soft parts, or even the exhibition of any cerebral symptoms worth mentioning. This circumscribed necrosis, involving both tables of the skull, could not have been produced by osseous inflammation, because that morbid process was not present at any time during the progress of the case; it could not have been produced by extravasation of blood into the pores and interspaces of the bruised bone, because the tissue of the necrosed fragments was clean, white, and not stained with blood, as it would have been under such circumstances; the conclusion is therefore irresistible that in this case a portion of living bone was killed outright by the stroke of the glancing projectile. By it a violent commotion was produced among the osseous particles, which must have proved highly detrimental to the integrity of the bone cells. Now, when we reflect upon the important office in the economy of the osseous tissue performed by the branched cells discovered by Virchow; that all the natural processes of the growth and decay, of the waste and repair of that tissue, are effected through the agency of these bone cells; that the office discharged by the bloodvessels of bone is, in reality, secondary to that fulfilled by the cells, for the vessels must be considered as the pipes through which nutritive and other material is brought into the interior of the osseous tissue, where it undergoes a variety of transformations through the instrumentality of the bone cells; bearing this in mind, it is easy to conceive that any agency which would greatly disturb the integrity and the relations of the bone cells would also destroy the vitality of the bone itself. Barwell says: "Bone consists of a number of branched cells, whose interstices (intercellular spaces) are occupied by a compound of cartilage and phosphate of lime, and among which vessels pass in a certain definite relation. By adopting this method of description, the different elements of which bone is composed are reduced to their proper relation—first the cells, then the cellular substance, and then the vascular supply." (*Barwell on the Joints*, p. 19, American edition.) The bone cells are, without doubt, the most important histological element which enters into the composition of bone. In the variety of osseous contusion now under consideration, may it not be true that the necrosis is due to the rupture of some of the bone cells, and the disturbance of the relations between others of them, occasioned by the commotion among the particles of the osseous tissue produced by the contusing force? The writer begs leave to commend this subject to the attention of all investigators in the domain of osseous pathology.

The separation of the dead from the living bone in this class of cases is accompanied with the following phenomena: From the living osseous tissue, where it borders on to the dead, the calcareous matter is gradually withdrawn by absorption under the local excitement produced by the dead bone acting as an irritant, and, at the same time, the bone cells and the connective tissue throughout the same locality assume the appearance of fleshy red granulations.[1] In this way the dead becomes separated from the living osseous tissue by a layer of florid soft granulations *formed at the expense of the living tissue*, which accounts for the fact that in the dried specimens of circumscribed necrosis the cavity is frequently found to be larger than the piece of dead bone which came out of it. This disparity in size is not due to a solution of the exterior of the necrosed fragment in the puriform fluid with which it is bathed, but to the beautiful process of conservation noticed above.

The case last narrated marched on to recovery without the occurrence of any untoward symptoms. The necrosed bone exfoliated, and was removed without any difficulty whatever. But we do not always have the same good fortune in the management of similar cases. That they do not always present the same freedom from suffering and danger will be perceived on the perusal of some of the following cases. While the process of exfoliation is taking place, an inflamed condition of the contiguous soft parts, attended with the formation of pus, is exceedingly apt to be present, and to inflict much suffering upon the patient. In occasional instances an inflammatory action is kindled in the surrounding osseous tissue, so severe in character as to terminate in inflammatory necrosis of a large part of the bone which had not suffered from the original injury; and in still rarer instances a suppurative inflammation is lighted up in the cancellous structure, or in the marrow, which may terminate in death by pyæmia before the process of exfoliation has been completed.

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[1] *Vide* Virchow's Lectures on Cellular Pathology, pp. 462–465. He says: "Granulations are nothing more than a young, soft, mucous tissue, analogous to marrow."

The following case will serve to illustrate the troublesome character of the sympathetic inflammation of the soft parts which is not unfrequently excited during the exfoliation of osseous tissue that has been deprived of its vitality by the stroke of a musket-ball:—

CASE IX. *Contusion of external malleolus of left ankle from fire-arms; exfoliation of the bruised osseous tissue; recovery.* Reported by John Moore, Med. Cadet U. S. Army.—Priv. Pat. McCabe, Co. "G," 87th Penn. Vols., aged 23, was admitted to Stanton General Hospital, July 4, 1864, having been struck by a musket-ball in front of Petersburg, Va., June 23d, which inflicted a flesh wound of the left ankle, about two inches in length, and in relation with the external malleolus. The bone proved to be contused, but its surface was not grooved, indented, fissured, or discoloured.

At the time of admission to hospital the limb was greatly swelled up to the knee, and the pain, throbbing in character, was very intense. The patient exhibited a good deal of constitutional disturbance, adynamic in character. The ice-dressing was applied to the inflamed parts, and stimulants and tonics (porter and iron) were given internally.

July 5. A flaxseed poultice was applied to the ankle, but it afforded no relief whatever. The swelling and pain continued unabated.

10*th.* An abscess having formed on the dorsum of the foot, it was evacuated by making a free incision, but the patient still continued to suffer a great deal of pain, and the swelling did not subside.

August 1. A thin narrow piece of bone about an inch in length exfoliated from the external malleolus, and was taken out of the wound. Subsequently another small piece of necrosed bone was removed. After the last piece of bone came away the patient began to improve rapidly. By the forepart of September the swelling had almost entirely disappeared, leaving only a moderate amount of thickening of the ankle. The pain had entirely disappeared.

Sept. 12. The patient is improving rapidly under potass. iodid. The thickening of the ankle has almost gone, and the wound is nearly healed. There is but little motion at the ankle-joint. He is in good condition and in fine spirits, although still confined to bed.

20*th.* He continues to improve rapidly, and leaves the bed daily to sit up in a chair.

25*th.* He begins to walk with crutches.

Oct. 3. He left the hospital on furlough for sixty days.

It is an interesting fact that in this case, as in the last, it required about six weeks to complete the process of exfoliation, and that, although the injury was sustained in close proximity to one of the largest of the articulations, he made a good recovery with what it was thought would prove to be a useful limb in the end. The process of separating the dead from the living osseous tissue (exfoliation) in this case was accompanied by much inflammatory excitement in the adjacent parts, and by the formation of an abscess on the dorsum of the foot which required to be treated by free incisions. This inflamed condition of the ankle was attended with a good deal of pain, because both the joint cavity and the dense periarticular tissues were involved in the swelling. This inflammatory mischief was kept up by the irritation occasioned by the presence of dead bone in the midst of sensitive living tissues. It was highly interesting to notice the rapidity with which the patient improved so soon as all the necrosed bone had come away. The pain ceased at once, the constitutional disturbance disappeared, and the swelling subsided in a short time.

Another interesting fact pertaining to this case is that the joint inflammation, although it lasted for so long a time, was not destructive in its character. It was not accompanied by the formation of pus in the interior of the articulation, and when the case was last examined by the writer there was still a small amount of mobility at the joint, but it probably terminated in complete anchylosis.

CASE X. *Gunshot wound of right hip; contusion of ilium; bullet lodged, and was extracted primarily through orifice of entrance; subsequently much constitutional disturbance, and much inflammatory mischief in soft parts; exfoliation of necrosed bone; convalescent.* Reported by Act. Asst. Surgeon G. W. Baker, U. S. Army.—Private Michael Mack, Co. "K," 96th Penn. Vols. was admitted to Stanton General Hospital, June 4, 1864, for a gunshot wound of the right hip. He was but seventeen years old, and stated that the wound had been inflicted in action near Mechanicsville, May 28th, by a minie ball. It penetrated the lateral surface of the right pelvic region about two inches below the crest of the ilium, and about the same distance behind the anterior superior spinous process of that bone. He also stated that the bullet lodged and was extracted the next day, through the orifice of entrance, while he was under an anæsthetic.

When he came to the hospital, exploration of the wound with the finger showed that the bullet had struck the bone, which was bare, but not fractured. He was able to get around on crutches, and the wound presented a healthy appearance, although the contiguous soft parts were a good deal swelled and inflamed. Prescribed the ice-dressing, and suitable alimentation.

Subsequently the discharge from the wound became very profuse. The swelling did not abate, but rather increased, and became indurated in feel. The wound did not heal up. After a time he had a great deal of pain in the wounded hip. It was also noticed that he was losing colour, flesh, and strength, and he became confined to his bed. It became obvious that he was steadily getting worse. Treatment, ice-dressing, tonics, nutrients, stimulants, and anodynes, *pro re nata.*

About the 20th of August the patient's appetite failed. His tongue also became coated, and he had considerable fever, with headache, and a frequent, quick, irritable pulse. He was very pale, and seemed to be failing rapidly. His bowels were regular. He complained much of pain in the wounded parts. Stimulants and anodynes were freely administered. The headache lasted only two or three days, and the febrile symptoms gradually became less intense, but the swelling of the wounded hip increased.

Sept. 9. An abscess of considerable size has appeared midway between the crest of the ilium, and the linea alba, and a little above the groins. He is pale, thin, weak, and exhibits a good deal of constitutional disturbance (irritative fever). Incised the abscess and ordered poultices to be applied.

18*th. Several small pieces of exfoliated bone came away from the gunshot wound.* This was followed by rapid improvement in every respect.

27*th.* Patient's general condition comfortable and favourable. The incised wound or opening in the abscess is nearly healed, but the bullet wound is still open.

Oct. 14. The parts contiguous to the bullet wound have again become swelled, inflamed, and very painful. An abscess is evidently forming near the bone. Incised it freely and evacuated a quantity of matter, which afforded great relief.

28*th.* The difficulty in the gluteal region has pretty much subsided. The discharge of pus is but moderate, and the amount of swelling but slight. The patient's general condition is excellent. The lips of the bullet wound pout as they would do if some flakes of exfoliated bone still lay behind.

CASE XI. *Gunshot wound, contusing the left tibia near knee-joint, inflicted by a glancing bullet; recovery.*—Corp. James Chaffee, Co. "I," 6th Ohio Cavalry, 20 years old, always healthy, was admitted to Stanton General Hospital, Oct. 17, 1863, from the field. He stated that he had been wounded three days before, Oct. 14, by a conical musket-ball, while engaged with infantry, near Bristow Station, Va. The bullet impinged obliquely upon antero-outer part of the head of the tibia (left) about two inches below the articular surface, and glanced off, without penetrating or fracturing the bone. The course of the bullet was from behind forward, and from without inward. Directed the water-dressing to be applied, and allowed a full diet.

Subsequently the wound granulated, but slowly. He had a good deal of pain in and about it. No pieces of bone were discharged, and the knee-joint did not become involved.

Dec. 10*th.* The wound was nearly healed, and he left the hospital on a furlough for thirty days.

Jan. 1, 1864 (about). An abscess formed in the popliteal space, and two days afterwards the wound reopened spontaneously.

April 1*st.* The wound is nearly filled up, but it presents a smooth, glazed, and indolent appearance. Its edges are blue and indurated. It is now circular in shape, and somewhat larger than a dime. Subsequently it healed slowly, and, April 24th, he was sent to his regiment for duty.

This case is introduced for the purpose of showing that even the lighter forms of contusion of bone may exert an unfavourable influence upon the curative process in the injured soft parts, causing the wound to be slow to heal, and liable to break out again with slight provocation, or even without any provocation at all. In this case the character of the injury, so far as the bone was concerned, was so slight that no exfoliation took place. There was at no time much inflammatory trouble in the soft parts, and no evidence whatever that the osseous tissue was suffering from inflammatory irritation. There was, however, in all probability, some inflammatory irritation in the periosteum at the place of contusion ; and this served to keep up an unhealthy condition of the neighbouring soft tissues.

Treatment of Contusion of Bone.—It is obvious that any plan of treatment, in order to be satisfactory, should be adapted to the pathological condition which it is intended to modify or remove. This proposition holds true with the morbid states of the osseous system, as well as with those pertaining to the other tissues of the body.

Now, it has been shown in the foregoing pages, that contusion may produce the following pathological conditions of bone: First, necrosis from interstitial hemorrhage (ecchymosis). Second, an inflamed condition of the bone, marrow, and periosteum, formative in character, and accompanied by new osseous growths, together with much inflammatory mischief in the surrounding soft parts. Third, inflammation of the bone (osteitis) more severe in character than the last mentioned, and terminating in necrosis (inflammatory necrosis). Fourth, suppurative osteo-myelitis. Fifth, gangrenous osteo-myelitis ; and Sixth, exfoliation of bone, the vitality of which has been destroyed primarily by the stroke of the contusing force. It may be advantageous to consider briefly the leading points in the treatment of each of these morbid states of the osseous tissue.

Necrosis from interstitial hemorrhage (ecchymosis) may occur in any of the bones which have a cancellous structure, but it is most frequently met with in the spongy epiphyses of the long bones. These cases are always likely to prove to be very serious on account of the inflammation, which sooner or later must be kindled in the surrounding parts by the dead bone. But, if the injury chances to be inflicted upon the epiphysis of a long bone close to one of the great articulations, such as the knee-joint, the gravity of the case will be very much increased. In such a case there will be no hope of recovery without amputation. Kimm's life was saved by a timely resort to that operation (*vide* Case I.), and Pryor died, that operation having not been performed (*vide* Case II.). In other cases it may be advisable to attempt to moderate the local inflammation, by quietude, by the local abstraction of blood, by the employment of the ice-dressing in the first stage, and by the use of fomentations in the second stage, and above all by the *early employment of free incisions*, so as to prevent the burrowing of matter among the muscles and in relation with the bone as much as possible. By pursuing this course the dead bone can be extracted at the earliest day practicable, and the neighbouring parts will have sustained the least possible amount of injury.

The treatment of the simple form of osteo-myelitis, or that inflamed condition of the bone, marrow, and periosteum, non-suppurative in character, and accompanied by the formation of a new bone, together with much inflammatory mischief in the surrounding soft parts, is attended by a serious difficulty, which arises from the fact that the pathological condition of the osseous tissue is apt to be entirely overlooked, as it was in the cases of Sted and Anderson (*vide* Cases III. and IV.), because it is masked by inflammatory mischief in the soft parts. Now, such inflammatory mischief in the soft parts is kept up through the agency of the osseous lesion. In the meantime the case may go on from bad to worse, and the surgeon wonders why it does so until he discovers the real difficulty, which lays behind the inflammation of the soft parts, and is located in the osseous tissue. Besides the local abstraction of blood, and the application of ice-dressings or fomentations and poultices, according as the one or the other of these topical applications shall afford the most relief to the patient; free incisions should be made into the inflamed parts as soon as any pus has been formed, with a view to secure its early evacuation, and to prevent any burrowing among the muscles and the deep-seated tissues. Anodynes should be administered to secure immunity from pain, and the patient's strength should be supported, especially in the advanced stages of the difficulty, by the judicious use of nutrients, tonics, and stimulants.

The treatment of acute osteitis (*inflammatory necrosis*), when it supervenes upon contusion of the osseous tissue, should be conducted upon the same general principles as those which pertain to the form of osseous inflammation considered above. Blood should be abstracted topically by leeches or cups, and ice-dressings, or hot fomentations and poultices, should be applied, consulting the feelings of the patient, and employing the one which affords most relief. It is a good plan to try the ice-dressing first, and then, if the result is not satisfactory, to exchange it for fomentations or poultices, and *vice versa.* In this class of cases long and deep incisions are generally demanded at an early day. The good effect of such incisions is illustrated by the case of Corporal Rall (*vide* Case V.). The liberal administration of anodynes will probably be demanded, and when the patient's strength begins to flag, it should be sustained by nutrients, tonics, and stimulants, *pro re nata.*

With regard to the suppurative and gangrenous varieties of osteomyelitis, the treatment must be guided by the general principles indicated above. Cases VI. and VII. afford melancholy examples of the inadequacy of all treatment for the cure of the worst forms. But even in them something may be done for the alleviation of suffering and for the prolongation of life. The prophylactic treatment, especially in hospital practice, is a matter of the first importance. To avoid the overcrowding of the patients, to secure an abundant supply of pure air for their use, to cause them to be kept as clean and comfortable as possible should be the special duty of the surgeon, for, by so doing, he will materially diminish the opportunities for suppurative and gangrenous osteo-myelitis to occur.

The next case is introduced for the purpose of illustrating the great value of free incisions in treating contusions and contused wounds of bone.

CASE XII. *Gunshot wound of the right hip; upper part of the femur furrowed and bruised by the bullet, which lodged in the thigh; violent inflammatory reaction in the soft parts, with protracted suppuration; recovery.* Reported by Frederick Rorboak, Medical Cadet, U. S. Army.—Private Charles Wheeler, Co. F, 4th Mich. Vols., aged 19, was wounded at Spottsylvania C. H., May 10th, 1864, by a musket-ball, which penetrated the right hip and lodged deeply in the thigh. He was admitted to Stanton General Hospital May 13th for treatment. The wound was inflamed, and the thigh was swelled, hot, and tender. Exploration of the wound showed that the bone was injured, but the bullet was not discovered. The ice-dressing was applied to the inflamed parts. The swelling of the thigh, however, did not abate, and the wound suppurated freely. During the latter part of May the patient's condition grew worse instead of better.

May 31. The injured limb is much swelled and inflamed. The wound discharges a thin, dirty-looking, stinking pus. It was judged to be expedient to explore the thigh in a more thorough manner than on previous occasions, with a view to ascertain the precise character of the bone-injury, and to extract the bullet if possible. Accordingly, an incision four inches in length was made on the outside of the thigh, from the great trochanter downwards, and penetrating to the bone. This enabled us to find that the bullet, which, having entered the hip two inches above and behind the trochanter major, had passed downwards, forwards, and inwards to a great distance in the soft tissues of the thigh, had also torn a groove on the surface of the great trochanter and the upper part of the femur, and bruised the osseous tissue. A careful and thorough search for the bullet was instituted; both the fingers and the porcelain-tipped probe of Nélaton were employed, but without success. The patient was labouring under an attack of rubeola when this operation was performed. Prescribed the water-dressing for the wounds, quietude in bed, with nutrients, tonics, and stimulants internally.

The character of the discharge from the wound was speedily improved, and the inflammatory action in the soft parts began to abate. Afterwards several small pieces of bone separated and came away from time to time. They were as thin as the finger-nail, and varied in breadth from an eighth to a quarter of an inch. Towards the end of August he began to leave his bed and to walk about on crutches.

Sept. 13. His general condition is good, his appetite and spirits excellent. Both the bullet-hole and the wound of operation are almost healed up, and present a healthy appearance. The amount of discharge is small and laudable in character. He can bear his weight upon the injured limb, by pressing upon that knee with both hands, so as to prevent it from gliding forward through debility on the part of the extensor muscles of the leg.

The writer fully believes that this man would have gradually wasted away, and died worn out by the protracted suppuration and by the irritation of the system at large set up by the morbid condition of the bone and the neighbouring soft parts, an unfortunate result which befell several of our cases, if he had not been treated by free incisions. Indeed, as it was, he got very much reduced at one time, and there even came to be much doubt as to his recovery. It is also probable that if the treatment by incision had been commenced at an earlier day, the patient would have been rescued from much suffering and peril, for, by this practice, judiciously employed, the extension of the suppurative process among the deep tissues of the thigh could, in a great measure, have been prevented.

With regard to the treatment which may be required by the exfoliation of osseous tissue whose vitality has been destroyed by the direct action of the contusing force, the first indication is to moderate, and keep under control the inflammatory excitement in the adjacent or contiguous tissues, whether osseous or soft, which the dead bone, acting as an irritant, will be likely to kindle. For such a purpose quietude, together with the ice-dressing and a spare diet, will generally suffice in the light cases, but the severe ones will demand also the abstraction of blood by leeches or cups, and the internal use of the cooling saline draughts, with opium in some form to allay pain. If any matter forms, it should be evacuated without delay. When the dead bone becomes detached it should, as a general rule, be extracted as soon as possible. Concerning the treatment of this form of exfoliating bone, reference may be advantageously made to Cases VIII., IX., and X. This form of necrosis becomes most dangerous to life when it rouses *a suppurative inflammation of the osseous or of the medullary tissue.* Illustrations of the fatal character of such osseous inflammation are not unfrequently furnished by the occurrence of suppurative inflammation of the diploë and consecutive thrombosis of some of the sinuses of the brain, while a contused patch of the cranium is being exfoliated. To prevent such unfortunate results, the prophylactic treatment of this class of cases becomes a matter of the first importance. These patients should not be crowded together, nor placed in a contaminated atmosphere. They should be provided with spacious and well-ventilated quarters. They should also be kept as clean, quiet, and comfortable as possible. By doing this, the surgeon accomplishes a great deal for the prevention of the destructive forms of osseous inflammation which sometimes follow contusion.

The following is, in some respects, a very instructive case:—

CASE XIII. *Contusion of the right tibia near its upper extremity, from the kick of a horse; exfoliation of necrosed bone; recovery.* Reported by Acting Asst. Surg. Charles H. Osborne, U. S. Army.—Corp. James H. Stewart, Co. H, 1st Vermont Cav., aged 22, was admitted to Stanton General Hospital, August 15, 1864, for an injury inflicted by the kick of a horse, which had bruised the right leg a short distance below the tubercle of the tibia, and produced a small abrasion of the cuticle. This was scabbed over, but it was also surrounded by a bright-red areola of inflammation about an inch in width, measuring from its inner to its outer margin. His general condition was poor, and he showed the usual symptoms of malarial poisoning. He did not complain of any pain other than a moderate amount of soreness. The water-dressing was applied, and full diet with stimulants allowed.

By the third day after he came to hospital the scab was removed, and a small ulcer with raised edges and pale granulations was exposed to view. Argenti nitras was applied, and the dressing was changed to unguent. resinæ. Tinct. ferri sesquichlorid. was added to the internal treatment.

The ulcer remained in the condition above mentioned, showing no tendency to heal until Sept. 1st. At this date he took a chill, his tongue became coated in the centre, and red and cracked at the tip and edges. Fever of a low type followed. His bowels inclined to be constipated, and were relieved by laxatives. The swelling of the leg increased, the ulcer assumed a phagedenic character, extending rapidly and discharging a thin pus. Nitric acid was applied to it, quinia, iron, opium, gr. j, every four hours, and stimulants were administered internally. From this time the fever gradually abated. After a time the slough separated and healthy granulations appeared. *A small flake or lamina of bone, about the size of the little finger-nail exfoliated and was removed.*

Oct. 12*th*. General condition much improved; appetite and spirits good; the ulcer is about an inch in diameter, healthy in appearance, and secretes a laudable pus. It is granulating rapidly and beginning to cicatrize.

18*th*. He is almost well; and able to undertake a journey of several hundred miles. He was transferred to General Hospital in his own State to-day.

This man's attending surgeon, Dr. Osborne, was not fully satisfied that the case belonged to the same category as osseous contusion, until the exfoliation of bone took place.

It is probable that the sloughing was principally due to an effort on the part of nature to secure a free aperture of communication with the bruised periosteum and bone, at an early day. Would not this patient have been benefited by a free incision down to the injured bone, made with the knife, when the bruise commenced to slough, or even prior to that time? Ought not the surgeon to take his cue from nature in such cases, at least so far as this point in the treatment is concerned?

An analysis of our cases yields the following results with respect to their causation, viz., in six of them the injury of the osseous tissue was produced by spent bullets, and in each of these six cases the bullet either lodged or was accidentally withdrawn through the orifice of entrance; five cases were hurt by glancing bullets; one was injured by a grazing bullet; and one by the kick of a horse. It is fair to suppose, also, that in at least some of the six cases wounded by glancing and grazing bullets, the projectile was not moving at anything like its maximum rate of speed. Now, this coincidence between the occurrence of contusion of bone and a greatly diminished velocity on the part of the projectile inflicting it, is certainly remarkable. It is also a fact of practical value to the military surgeon. It will lead him to anticipate serious consequences in all cases where a spent bullet has struck a bone, and to make timely preparations to meet them.

With regard to the influence of the state of the constitution upon the results of contusion of bone, it should be stated that all of our cases occurred in the persons of soldiers in the prime of manhood, and free from constitutional taint in any form, that none of them were old or otherwise broken down, and that but three of them were at all debilitated at the time of injury.

With regard to the results, it should be stated that of the thirteen cases (this enumeration of course embraces the one kicked by a horse), one suffered amputation of the thigh, five died, and seven made more or less complete recoveries. This certainly exhibits a high rate of mortality, and serves well to illustrate the serious character of the lesion.

It has been stated incidentally that the pathological conditions of the bone produced by contusion are apt to be masked by the swollen and inflamed state of the overlying soft parts, so that the osseous lesion may escape notice for some time. This happened in no less than three of our cases, and it should serve as a warning to all surgeons to be vigilant while treating this class of cases.

The facts and observations set forth in the preceding pages have shown at least some of the serious consequences which are produced by contusion of bone. It could scarcely be expected that all of them would be successfully pointed out by any one surgeon, however extensive his experience in osseous pathology may be. But enough has been shown at least to indicate that any injury of bone in the nature of a bruise, however trivial it may appear to be at the time of infliction, may be followed by serious consequences, which it is the duty of the surgeon to anticipate and ward off if possible.

HEAD-QUARTERS ARMY OF THE POTOMAC, March 22d, 1865.

ART. II.—*Diphtheria, as it prevailed in Accomac County, Va., and its most Successful Mode of Treatment.* By EDWIN W. LE CATO, M. D.

EARLY in the autumn of 1863 the lower portion of Accomac County, Va., was visited by an epidemic entirely unlike anything that had previously prevailed, and consequently most of us were wholly unprepared to decide upon its character or how to treat it. In the beginning, a few of the profession believed it to be tonsillitis, others, putrid sore throat, ulcerated sore throat, &c.; and not a few cases occurred before the true character of the disease was fully understood. But the great fatality of the malady soon convinced those who were in doubt, that the disorder was widely different from the anginose affections prevalent in this part of the world. It is now admitted by all to be what it really is—diphtheria.

The popular belief that the disorder was eminently contagious caused for a while much consternation in the community, greatly abridging social